### Calculator Use in the United States and Other Countries

Handheld calculators are owned by almost every student in the United States and are fully integrated into the teaching of mathematics in many U.S. schools. Since 1985, many calculator models have featured built-in graphing software for enhancing teaching and learning by allowing mathematics students to visualize mathematical functions.

The NCTM Curriculum and Evaluation Standards (NCTM 1989) urge the use of calculators to reduce the time spent on paper and pencil methods of calculating so that students can have more time to work on problems that foster development of underlying concepts. NCTM suggests that by using this approach, students develop a stronger basis for understanding how to approach complex problems. Meanwhile, educators who do not share this view have expressed concern that young children in classrooms where calculators are heavily used may not develop proficiency with basic arithmetic operations. See sidebar, "Calculators and Achievement."

Both the NAEP and TIMSS surveys included questions for teachers and students on their level of calculator use in schools. The TIMSS surveys show that 99 percent of 8th-grade students and 95 percent of 4th-grade students in the United States owned calculators in 1995. The range was from 76 percent in Norway to 95 percent in the United States and the Czech Republic. In the United States, many schools provide calculators for use by students who do not own them. School-owned calculators used in 4th-grade U.S. classrooms increased from 59 percent to 84 percent between 1992 and 1996 (Hawkins, Stancavage, and Dossey 1998).

Classroom use of calculators is more common among U.S. elementary school students than among students in a number of other countries that participated in TIMSS. (See text table 1-7.) Although U.S. teachers were more likely than teachers in most other countries to use calculators in the lower grades, about 30 percent still reported that they never use calculators. However, about the same percentage of these teachers reported using calculators to solve complex problems in 4th-grade classrooms, a proportion similar to that for teachers in Canada and England (Mullis et al. 1997).

By grade 8, classrooms in nearly all countries use calculators for mathematics instruction, although the degree to which they are used varies widely. In 1999, 42 percent of U.S. 8th-grade students reported that they "almost always" use calculators in their mathematics lessons (Mullis et al. 2000). This percentage was higher than the international average (19 percent). Compared to the United States, two nations, the Netherlands and Australia, had a higher percentage of students responding that they almost always use calculators in their mathematics lessons. Eight percent of U.S. 8th-grade students reported never using calculators in their mathematics lessons, which was lower than the international average for students (32 percent).

Official policies on calculator use vary across the countries participating in the TIMSS-R; policies include encouraging unrestricted use, use with restrictions, and banning calculator use entirely (Mullis et al. 2000). Official documents of 23 countries included an explicit policy on the use of calculators. (See text table 1-8 for policies in selected countries.) Seven of these countries reported that their curriculum policy allows unrestricted use of calculators (Belgium, Finland, Hong Kong, Israel, Japan, the Netherlands, and New Zealand), and 14 allow restricted use. In Canada and the United States, policy varied across provinces and states, respectively. Several countries' policies do not permit calculator use in the lower grades of their primary school systems. For example, in Japan, calculators are not permitted until grade 5. Other countries reported that the use of calculators in these lower grades is limited so that students may master basic computational skills, both mentally and using pencil and paper.

## Transition to Higher Education

Expectations of college attendance have increased dramatically over the past 20 years, even among low-performing students. More than two-thirds of high school graduates attend college, and a rising proportion have taken a college preparatory curriculum in high school. The use of AP exams to gain college credit in high school has also increased, although research has shown that some colleges are less likely to award AP credit now than in the past. Despite greater numbers of students aiming for college, some college faculty are concerned that today's students are less well prepared in mathematics than previous generations of students. College-level remediation is also on the rise, and policymakers are increasingly concerned about the number of students needing to take remedial courses in college. This section reviews changes in the immediate transition from high school to college over the past 30 years, including changes by sex and by race/ethnicity. The final section discusses the growth of remediation at the college level, a trend that troubles both educators and policymakers who are concerned about the efficacy of the S&E pipeline.

### Transition from High School to College

Because most college students enroll in college immediately after completing high school, the percentage of high school graduates enrolled in college the October following graduation is an indicator of the total proportion who will ever enroll in college. College enrollment rates reflect both the accessibility of higher education to high school graduates and their assessments of the relative value of attending college compared with working, entering the military, or pursuing other possibilities.

Overall, immediate college enrollment rates for high school completers increased from 49 to 63 percent between 1972 and 1999. (See figure 1-20.) Much of the growth in these rates between 1984 and 1999 was due to increases in the immediate enrollment rates for females at four-year institutions (see below).

Some differences in immediate enrollment rates among groups of completers have not changed. The gap in rates be-

Text table 1-7.
**Student mathematics score and percentage of students and teachers reporting hand-held calculator use in 4th and 8th grades, by country: 1995**

| Country | Average mathematics score (mean) | | Calculator use and access (%) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | 4th grade | | | | | | |
| | | | Students | | Teachers | | 8th-grade teachers | | |
| | 4th grade | 8th grade | Have calculators at home | Never use in class | Never use in class | Use for complex problems | Never use in class | Use daily | Use for complex problems |
| Singapore | 625 | 643 | 93 | 96 | 97 | 1 | 1 | 82 | 82 |
| South Korea | 611 | 607 | 87 | 93 | 86 | 3 | 76 | 1 | 4 |
| Netherlands | 577 | 541 | 93 | 90 | 85 | 2 | 0 | 81 | 67 |
| Czech Republic | 567 | 564 | 95 | 63 | 54 | 8 | 3 | 74 | 80 |
| Austria | 559 | 539 | 95 | 96 | 98 | 0 | 2 | 87 | 70 |
| Ireland | 550 | 527 | 95 | 91 | 88 | 3 | 68 | 11 | 7 |
| United States | 545 | 500 | 95 | 34 | 29 | 26 | 8 | 62 | 76 |
| Hungary | 548 | 537 | 95 | 90 | 78 | 5 | 29 | 60 | 53 |
| Canada | 532 | 527 | 95 | 51 | 37 | 23 | 5 | 80 | 86 |
| England | 513 | 506 | 95 | 15 | 8 | 28 | 0 | 83 | 73 |
| Norway | 502 | 503 | 95 | 89 | 93 | 1 | 2 | 82 | 72 |
| New Zealand | 499 | 508 | 95 | 18 | 5 | 50 | 7 | 66 | 70 |

SOURCES: I. Mullis, M. Martin, A. Beaton, E. Gonzalez, D. Kelly, and T. Smith, *Mathematics Achievement in the Primary School Years: IEA's Third International Mathematics and Science Study (TIMSS)* (Chestnut Hill, MA: Boston College, TIMSS International Study Center, 1997); and A. Beaton, M. Martin, I. Mullis, E. Gonzalez, T. Smith, and D. Kelly, *Science Achievement in the Middle School Years: IEA's Third International Mathematics and Science Study (TIMSS)* (Chestnut Hill, MA: Boston College, TIMSS International Study Center, 1996). *Science & Engineering Indicators – 2002*

## Calculators and Achievement

Although the National Council of Teachers of Mathematics (NCTM) recommends the integration of calculators into the school mathematics program at all grade levels (NCTM 1989), research on the effect of calculator use on achievement is not definitive. Some studies have concluded that calculator use does not undermine basic skills (Hembree and Dessart 1986, Suydam 1979) and that calculator use has a positive effect on achievement in early grades (B. Smith 1996, Hembree and Dessart 1986). Critics, however, have pointed to deficiencies in the majority of studies supporting calculator use. Many of these studies were of short duration, lasting only a few weeks, and lacked sufficient controls to equate comparable groups or to screen out other influences on student outcomes (Loveless and Diperna 2000).

A recent Brookings Institution study (Loveless and Diperna 2000) examining test results from both the National Assessment of Educational Progress (NAEP) and the Third International Mathematics and Science Study (TIMSS) raises additional questions about the influence of calculator use on achievement. For example, in both NAEP and TIMSS, students were asked how often they use calculators in class. On both tests, calculator use is correlated with lower math scores. On the 1996 National NAEP Mathematics Assessment, 4th graders who reported that they used calculators in class every day had the lowest NAEP scores of any response category. Students who reported using calculators only once or twice per month had the highest scores. A similar pattern was evident on 4th-grade TIMSS. Frequent calculator use is negatively correlated with math achievement in several countries. A vast majority of 4th-grade students in the highest scoring nations (Japan, Singapore, and South Korea) report that they never use calculators in math class.

Although Loveless and Diperna acknowledge that these results do not necessarily imply that calculator use results in lower academic achievement (low math skills may actually push individual students to rely on calculators more), their findings suggest that additional, high-quality research on the use of calculators at the elementary level is warranted, particularly because of the equity issues involved. In 1996, black and Hispanic students were about twice as likely as white students to report that they use calculators every day (Loveless and Diperna 2000).

tween those from high- and low-income families persisted for each year between 1990 and 1999. Likewise, completers whose parents had attained a bachelor's degree or higher were more likely than those with parents who had less education to enter college immediately after high school graduation for each year between 1990 and 1999 (NCES 2001b).

## Transition Rates by Sex

Females are slightly more likely than males to make an immediate transition from high school to college. Between 1972 and 1999, immediate enrollment rates for female high school graduates increased faster than those for males. (See

figure 1-20.) Much of the increase between 1984 and 1999 was due to increases in female enrollment rates at four-year colleges, which rose from 34 to 43 percent over this 15-year period. In 1999, the enrollment rate at four-year institutions was 43 percent for females compared with 41 percent for males. That year, females were about as likely as males to enroll in two-year institutions after high school graduation (both about 21 percent) (NCES 2001b).

Although males and females are similarly prepared to enter the math and science pipeline upon entering college, a large gender gap occurs in the selection of college majors (see sections on achievement and coursetaking in this chapter and chapter 2). However, the divergence in interest in math and science careers may start much earlier.

Text table 1-8.
**Policies on calculator usage in selected countries/economies participating in TIMSS-R: 1999**

| Country/economy | Type of policy | Comments |
|---|---|---|
| Australia | Unrestricted | Calculators are unrestricted as a learning tool. Computational skills like mental arithmetic are also promoted. |
| Belgium (Flemish) | Restricted | Calculators are permitted on a limited basis so that students can master the basic skills of computation and mental calculation. Calculator use increases and is compulsory after grade 9. |
| Canada | Unrestricted, 2 provinces; restricted, 8 provinces | In general, calculator use is encouraged, except in lower grades in some provinces. |
| Taiwan | Restricted | Calculators are not allowed on entrance exams, so teachers can limit their use in classroom. |
| Czech Republic | Restricted | Computational skills are practiced without calculators. |
| England | Restricted | Calculator use increases as students progress through school. The emphasis is on pupils having a range of skills: calculator, pencil and paper, and mental computation. Graphic calculators are required at higher levels. |
| Finland | Unrestricted | Although permitted at the lower levels, policy indicates that the use of calculators is more appropriate at the upper levels (grades 7–9). |
| Hong Kong | Unrestricted | Calculators may be used for exploration only from grades 1 to 6. No restrictions are set on the use of calculators for students from grade 7 onward. |
| Hungary | Restricted | Calculator use is considered appropriate in higher grades. |
| Indonesia | Restricted | Calculators are not permitted in lower grades. |
| Israel | Unrestricted | Calculators are permitted through all school levels (grades 1–12) |
| Italy[a] | | |
| Japan | Unrestricted | Calculators are not permitted until grade 5. |
| Netherlands | Unrestricted | Calculators are compulsory at national exam level. In grades 11–12, the graphic calculator is compulsory for mathematics students. |
| New Zealand | Unrestricted | The policy assumes that calculators will be available and used "appropriately" at all levels. |
| Russian Federation | Restricted | There is some use of calculators in elementary school. Recommended use of calculators on a level with oral and written calculations in secondary school. Students are not allowed to use calculators for public exams in grades 9 and 11. |
| Singapore | Restricted | In primary school, students are not allowed to use calculators in mathematics. In secondary school, the use of calculators is allowed from grade 7, although the use is restricted. |
| Slovenia[a] | | |
| South Korea | Restricted | Currently, calculators are not used in class. However, the new curriculum, to be implemented in 2000/01, recommends the wide use of calculators. |
| United States | Varies from state to state | |

[a]Curriculum does not contain recommendations about use of calculators.

SOURCE: I. Mullis, M. Martin, E. Gonzalez, K.D. Gregory, R.A. Garden, K.M. O'Connor, S.J. Chrostowski, and T. Smith. *TIMSS 1999 International Mathematics Report* (Chestnut Hill, MA: Boston College, TIMSS International Study Center, 2000).

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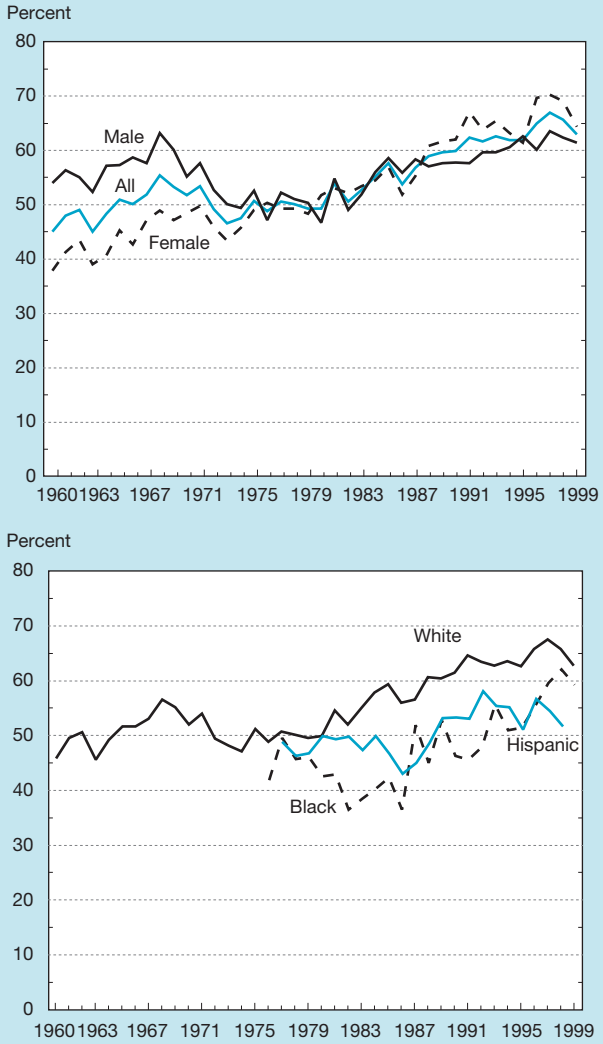
Figure 1-20.
**Percentage of high school graduates enrolled in college the October after completing high school, by sex and race/ethnicity: 1960–99**




NOTE: Data for Hispanics are calculated as three-year moving average.

SOURCE: National Center for Education Statistics, *The Digest of Education Statistics 2000*, NCES 2001-034 (Washington, DC: U.S. Department of Education, Office of Educational Research and Improvement: 2001b).

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## Transition Rates by Race/Ethnicity

College transition rates for white and black high school graduates have increased over the past 30 years, while rates for Hispanic graduates have been stable. (See figure 1-20.) Transition rates for white high school graduates increased from 50 percent in the early 1970s to about 60 percent in the mid-1980s and have fluctuated between 60 and 67 percent since then. After a period of decline in the late 1970s and early 1980s, the percentage of blacks enrolling in college immediately after high school graduation rose through the late 1980s, stagnated in the early 1990s, and increased again in the late 1990s. Since 1984, college transition rates for black graduates have increased faster than those for whites, thus closing much of the gap between the two groups. The enrollment rates for Hispanic graduates have shown no consistent growth since 1972, fluctuating between 45 and 65 percent from 1972 to 1997 (NCES 2001b).

The type of institutions that high school graduates first attend can affect their likelihood of completing a bachelor's degree. Students who begin their higher education at a two-year college are far less likely to earn a bachelor's degree than are their counterparts who begin at a four-year college. In 1994, white graduates were twice as likely to enroll in a four-year college as a two-year college after high school, black graduates were about 1.5 times as likely, and Hispanic graduates were equally likely to enroll in a four-year college as a two-year college (NCES 1996b).

Students who initially enroll part time in college are less likely to persist toward a bachelor's degree than those who enroll full time (NCES 1996b). Hispanic high school graduates ages 18–24 were far more likely to be enrolled in college part time, as opposed to full time, than were their white or black counterparts in 1994. (See sidebar, "Who Is Prepared for College?")

## Remedial Education in College

Many students enter postsecondary education institutions lacking the reading, writing, or mathematics skills necessary to perform college-level work. Therefore, most institutions enrolling freshmen offer remedial courses to bring these students' skills up to the college level (NCES 2000a). Although some consider remedial courses as one way to expand educational opportunities for students with academic deficiencies, others feel that remedial instruction should be eliminated or strictly limited in four-year institutions.

In 1995, all public two-year and 81 percent of public four-year institutions offered remedial reading, writing, or mathematics courses. Fewer private four-year institutions (63 percent) offered remedial courses in one or more of these subjects. (See figure 1-22.)

Public two-year institutions were more likely than either public or private four-year institutions to offer remedial courses because of their particular mission and the types of students they serve. In 1995, about one-half of public two-year institutions had open admissions compared with less than 10 percent of public and private four-year institutions (NCES 2000a). Freshmen at public two-year institutions were almost twice as likely as their peers at public four-year institutions to enroll in remedial courses in reading, writing, or mathematics (41 versus 22 percent) (NCES 2000a).

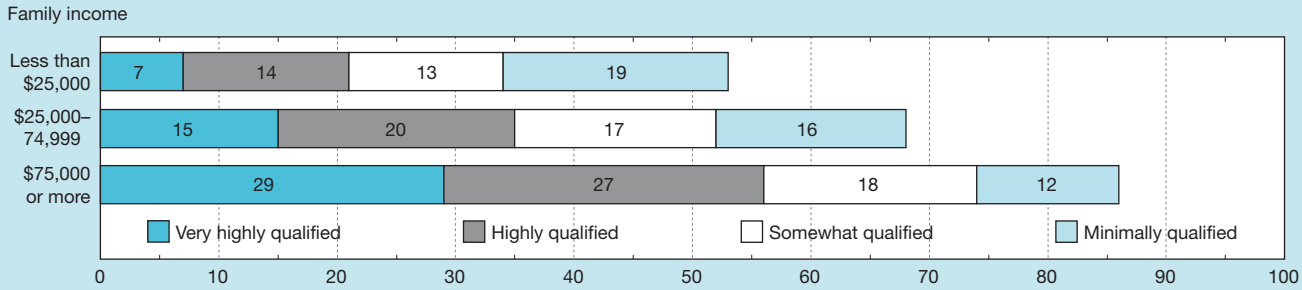
## Who is Prepared for College?

High school graduates from low-income families enter four-year institutions at lower rates than their higher income peers (NCES 2000a). Although financial barriers to college attendance exist for many low-income students, another reason for their lower enrollment rate is that they are less qualified academically. (See figure 1-21.) NCES constructed a 4-year College Qualification Index, based on high school grade point average, senior class rank, aptitude test scores from the National Educational Longitudinal Study of 1988, SAT or ACT scores, and a measure of curricular rigor (see NCES 2000a for details). On this index, 86 percent of 1992 high school graduates from families with high incomes ($75,000 or more) were at least minimally academically qualified for admission to a four-year institution compared with 68 percent of those from middle-income ($25,000 to $74,999) and 53 percent from low-income (less than $25,000) families. Moreover, high-income graduates were almost twice as likely as middle-income graduates and four times as likely as low-income graduates to be very highly qualified for four-year college admission. The proportion of college-qualified students was also directly related to their parents' educational attainment.

Asian/Pacific Islander and white graduates have higher average family income and parental education levels than their black and Hispanic counterparts. Reflecting this pattern, Asian/Pacific Islander and white graduates were more likely than black and Hispanic graduates to be at least minimally qualified for four-year college admission. The proportion of very highly qualified graduates was largest among Asians/Pacific Islanders.

SOURCE: NCES 2000a.

Figure 1-21.
**Percentage of 1992 high school graduates qualified for admission at a four-year institution, by level of qualification and family income**




NOTE: Four-year college qualification index is based on high school grade point average, senior class rank, National Educational Longitudinal Study (NELS) 1992 aptitude test, SAT scores, and a measure of curricular rigor.

SOURCE: National Center for Education Statistics, *The Condition of Education 2000*, NCES 2000-062 (Washington, DC: U.S. Department of Education, Office of Educational Research and Improvement: 2000a).

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## Conclusion

This chapter presented indicators of the status and change in U.S. elementary and secondary schools regarding student achievement, math and science coursetaking, implementation of content standards and state-level testing, curriculum structure and amount of time allocated to math and science compared with other countries, teacher quality (including initial training and professional development), teacher working conditions, access to and use of technology in schools, and transition to higher education. Although these indicators do not tell the whole story, they do highlight improvements in our K–12 education system over the past few decades while pointing to areas of enduring concern.

Observations made about U.S. mathematics and science education in 1947 noted that textbooks were thick and included unnecessary information and that teachers did not have sufficient training in mathematics (NSB 2000). Significant efforts have been made to reform elementary and secondary schools since 1947, such as those stimulated by *Sputnik* in 1957, the National Commission on Excellence in Education in 1983, and the National Education Goals that grew out of the Governor's summit of 1990. The national policy goals and educational standards for mathematics and science education set new and higher expectations for U.S. schools, students, and teachers. The indicators in this chapter were chosen to measure how close the nation has come to meeting those expectations.

A higher proportion of students graduate from high school with advanced courses in mathematics and science than did their counterparts three decades ago. As measured by NAEP, student achievement in mathematics and science has increased since the mid-1970s, although relatively few students are attaining levels deemed Proficient or Advanced by NAGB, and the performance of U.S. students continues to rank substantially below that of students in a number of other countries. Furthermore, the relative performance of U.S. students compared to their counterparts in other countries appears to de-